ATOMIC ENERGY FOR INDUSTRY

by

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	PAGE
STEPS TOWARD COMMERCIAL ATOMIC POWER	219
Plans for Private Building of Power Reactors	219
A.E.C. Experiments in Atom Power for Industry	222
Package Power Plants and Propulsion Reactors	224
INTERNATIONAL ATOMIC ENERGY DEVELOPMENTS	226
Action to Carry Out U. S. Atoms-for-Peace Project	226
Plans to Produce Atom Power in Britain and Russia	227
Research on Power for Industry in Other Countries	228
ATOMIC ENERGY AND WORLD POWER DEMANDS	229
Scarcity of Standard Fuels; Need for New Energy	229
Atomic Power in Backward and Advanced Countries	229
Nuclear Energy and Development of New Industries	231
ECONOMIC FEASIBILITY OF NUCLEAR POWER	233
Problem of Making Atom Power Costs Competitive	234
Barriers to Early Attainment of Commercial Power	235

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ATOMIC ENERGY FOR INDUSTRY

ELECTRIC POWER generated by an atomic reactor at a government-built and operated experimental facility at West Milton, N. Y., is expected to become available in limited quantities for commercial use late in the summer of 1955. Electricity produced by the country's first full-scale nuclear power plant, a joint government-private utility venture, may go on the market by 1957. The first offer to construct an atomic electric power plant without government assistance was announced last month, and the Atomic Energy Commission has invited private companies to submit proposals by Apr. 1 for building and operating other power reactors.

Research and experimentation in the adaptation of atomic energy to industrial use have progressed to a point where the experts, formerly absorbed in the problems of nuclear technology, are now concerned also with the economics of nuclear power. Development of the atomic-powered submarine *Nautilus* from the idea stage to seagoing ship in half-a-dozen years suggests the advances that have been made in nuclear science. A.E.C. Chairman Lewis L. Strauss nevertheless cautioned the congressional Joint Committee on Atomic Energy, Jan. 31, that although nuclear power was now a reality, "Low-cost competitive power for our homes and industries . . . is an ambition and a challenge, rather than a reality."

Plans for Private Building of Power Reactors

Ten years after the first atomic explosion in New Mexico, private industry is taking steps to build and operate its own, as distinct from the government's, atomic power reactors. H. R. Searing, president of the Consolidated Edison Co. of New York, disclosed on Feb. 10 that his company planned to construct at Indian Point, between Peekskill and Croton-on-Hudson, N. Y., a 100,000-200,000 kilowatt nuclear electric power plant—the first in the country that will be privately

financed, built, and operated. Testifying before the Joint Committee on Atomic Energy, Searing said:

> We believed that the proper approach was to consider a reactor in the same manner as we would any other addition to our system and to go about . . . purchasing . . . a reactor in the same way we would go about the purchase of any other addition. . . . The second fundamental principle was that we would finance the plant ourselves and that we would not seek government assistance. . . . In other words, our chief objective has been to get something done, for we firmly believe that only by actual construction of projects can the [nuclear] art be placed on a commercial basis.

Consolidated Edison announced on Mar. 22 that it had made formal application to the Atomic Energy Commission for authority to build and operate the Indian Point plant. Searing has said that it will be at least a year before construction can get under way and four years before the plant will be ready for service.[1]

However, the first full-scale nuclear electric power plant in the United States may go into operation as early as 1957. A joint undertaking of the Atomic Energy Commission and the Duquesne Light Co. of Pittsburgh, the plant now under construction at Shippingport, Pa., will produce a minimum of 60,000 kilowatts of salable electricity. The contract negotiated by the A.E.C. and Duquesne last year provided that the utility company would (1) build and operate the electric generating portion of the plant; (2) operate the reactor portion and assume $5 million of the estimated $85 million cost of developing and constructing the reactor; and (3) purchase, at specified rates, the steam generated by the plant.

The Duquesne project will make possible "firm cost estimates for the future," the A.E.C. has observed, "and [will] provide design and technological experience obtainable only from a full-scale plant operation."[2] A Joint Atomic Energy subcommittee reported in March a year ago that, although the type of reactor chosen for the Shippingport project was "clearly of conservative design and . . . a poor long-term prospect for producing low-cost atomic power," it was the "one approach . . . ready for full-scale construction as a demonstration of the generation of electricity from atomic energy."

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[1] It has been reported that the Detroit Edison Co. will announce plans soon to build a 100,000-kw reactor. The Yankee Atomic Electric Co., organized by 12 New England power companies, is said to be planning a 200,000-kw nuclear electric power plant. Babcock & Wilcox Co., Combustion Engineering, Inc., and General Electric have announced plans to manufacture nuclear power equipment.

[2] A.E.C., *Major Activities in the Atomic Energy Programs, January-July 1954* (July 1954), p. 21.

To encourage private construction of other atomic power plants, the A.E.C. on Jan. 9 announced launching of a "power demonstration reactor program." The program will afford assistance to private companies undertaking to build, own, and operate atomic reactors that are "designed to demonstrate the practical value of such facilities for industrial or commercial purposes." K. D. Nichols, general manager of A.E.C., told the Joint Atomic Energy Committee, Jan. 31, that the commission hoped to receive at least four proposals in the next two months.

When the A.E.C. has approved a proposal, it will make nuclear fuel available to the company free of charge, offer research and development assistance at A.E.C. laboratories, and pay for technical and economic information growing out of the project. Chairman Strauss has said the power demonstration program was initiated in the belief that "The greatest advances in reactor technology will come from the actual construction and operation of large-scale reactors on a commercial basis."

Easing of Restrictions on Private Action in 1954

The power demonstration program was the A.E.C.'s first major move to fulfill one of the aims of the Atomic Energy Act of 1954. That law, approved Aug. 30, sought to make it possible for private enterprise to participate more actively in the development of atomic power. It removed many of the legal barriers to non-government activity in the atomic energy field and modified the "monopolistic provisions of the old statute." [3]

The Atomic Energy Act of 1946 had prohibited private ownership of fissionable materials. The 1954 act permits private ownership of "source" materials (uranium, thorium, and ores containing them). It continues to restrict ownership of "special nuclear" materials (plutonium, U-233, and U-235) to the government, but provides that such materials may be used under license for a fee. Private ownership of "by-product" materials (yielded in, or made radioactive by, the production or utilization of special nuclear materials) also is allowed. Whereas the 1946 act barred private ownership of facilities for production of special nuclear materials, the new act allows licensed ownership of such facilities.

The A.E.C. sets the prices to be paid by licensed companies

[3] Address by A.E.C. Chairman Strauss, National Press Club, Jan. 11, 1955.

buying or leasing source materials, and the fees for use of special nuclear materials; also the prices it will pay for any special nuclear materials the licensed companies may produce. Licensees are to be charged for any services performed for them by the A.E.C. Schedules of charges for materials and services have been established, but drafting of regulations is still under way.[4]

Licenses for facilities for producing or utilizing special nuclear material may be issued for commercial purposes, medical therapy, or research and development purposes. Commercial licenses must be withheld, however, until the A.E.C. has determined that the particular type of facility has been "sufficiently developed to be of practical value for industrial or commercial purposes." Because it is likely to be "some years before reactor technology has been developed to the point where the Commission would be justified" in issuing commercial licenses, the licenses issued in the near future—aside from those for medical therapy and general research purposes—probably will be for facilities "involved in research and development leading to the demonstration of commercial practicability." [5]

Meanwhile, the Joint Committee on Atomic Energy has appointed an eight-man panel of scientists and businessmen to make a broad study of peaceful uses of atomic energy. The panel is to recommend by Jan. 31, 1956, any action needed "to speed the proper development of peaceful uses of atomic energy under both government and private auspices."

A.E.C. Experiments in Atom Power for Industry

About a year ago the Atomic Energy Commission embarked on a five-year, $200 million program looking to development of nuclear power by methods and at costs that would make it practical for use by industry.[6] The program

[4] Sen. Gore (D-Tenn.) and Rep. Holifield (D-Cal.) of the Joint Committee complained early in March that, although six months had gone by since passage of the 1954 act, the A.E.C. still had not shown industry how to proceed. However, when Joint Committee Chairman Anderson (D-N.M.) asked President Searing of Consolidated Edison on Feb. 10 whether early promulgation of rules would not "make it a little more attractive to more firms . . . to come forward," Searing replied: "I don't think so. I think the firms will have to make up their minds first, and . . . the papers and forms will follow."

[5] George G. Manov, office of assistant general manager for research and industrial development, A.E.C., address before National Association of Manufacturers, St. Louis, Nov. 17, 1954.

[6] An A.E.C. policy statement, submitted to the Joint Committee in May 1953, called "attainment of economically competitive nuclear power . . . a goal of national importance" and noted a need "to promote the construction of experimental reactors." The Joint Committee, two months later, requested A.E.C. to prepare a reactor development program. The A.E.C. submitted its proposals in February 1954, and the committee approved them the following month.

provided for experiments with five different types of reactors, selected from around 80 possible types as those most likely to lead to production of electric power at costs competitive with power generated by conventional methods. The A.E.C. informed the Joint Committee that the five-way approach had been adopted "because it has not yet been learned which is the ideal or even the best choice." The pressurized water reactor, now being built at Shippingport, Pa., is a full-scale experimental project; the other reactors are to be only pilot-size models.

Three of the five reactors—the homogeneous, sodium graphite, and pressurized water—were under construction by January 1955. Chairman Strauss said at that time he was hopeful of building "at least one reactor a year for the next several years." None of the five reactors promises itself to produce economically competitive electric power, but each is expected to help in providing a foundation upon which government or industry can work toward that goal.

CONSTRUCTION OF CIVILIAN POWER REACTORS

Type of reactor	Location	Completion date	Output (kw)
Homogeneous *	Oak Ridge, Tenn.	1955	300
Sodium graphite	Santa Susana, Cal.	1955	None
Boiling water	Chicago (Argonne)	1956	5,000
Pressurized water	Shippingport, Pa.	1957	60,000
Fast breeder	Not yet selected	1958	15,000

* A variant of the homogeneous reactor (homogeneous thorium), with an output of 16,000 kw, is scheduled for completion in 1959 at a site not yet selected.

The A.E.C.'s 1953 policy statement voiced the conviction that "Progress toward economic nuclear power can be further advanced through participation in the development program by qualified and interested groups outside the Commission." Private industry study groups actually had been participating to some extent since 1951. Starting with four groups, consisting of eight companies,[7] A.E.C.'s industrial participation program had grown by the end of January 1955 to embrace 19 groups, comprising a total of 71 companies.[8] More than $8 million in industry funds was expended on the program between mid-1951 and January 1955; one of the study groups, Atomic Power Development Associates, has announced a 1955 budget of $3.8 million.

[7] (1) Commonwealth Edison Co. and Public Service Co. of Northern Illinois; (2) Dow Chemical Co. and Detroit Edison Co.; (3) Monsanto Chemical Co. and Union Electric Co.; (4) Pacific Gas & Electric Co. and Bechtel Corp.

[8] The 71 companies included 45 utilities, 10 equipment manufacturing, 9 engineering and construction, 5 chemical, and 2 shipbuilding companies.

It is the function of the cooperating companies to determine the engineering and economic feasibility of reactors, and to make recommendations to the A.E.C. on the use of nuclear power and on industry's role in its development.

Package Power Plants and Propulsion Reactors

In addition to promoting development of large-scale, stationary nuclear power plants to generate electricity, the Atomic Energy Commission has been forwarding experiments on small-scale and propulsion reactors. A contract to design, build, and test-operate a prototype of a package nuclear power plant for military use was let last December to the American Locomotive Co. The Army Package Power Reactor, known as A.P.P.R., is to be constructed at Fort Belvoir, Va., at a cost of about $2.1 million.

Defense Department specifications called for a nuclear power plant, whose major components could be transported by air, to supply heat and light at remote and relatively inaccessible military installations. The A.P.P.R., a pressurized water reactor capable of producing about 2,000 kilowatts of electricity, is intended to meet the needs of military installations in the Arctic. Chairman Strauss said on Jan. 11 that it should be completed by 1958.

The package power plant promises numerous advantages. Its small size will make it relatively easy to move, and its use will render unnecessary the transport of large quantities of bulky conventional fuels. Experience with the small plant, moreover, should contribute to the general development of commercial atomic power. Commissioner Libby reported on Feb. 1 that private industry was showing great interest in the package power project; he said that "The small package power plant concept . . . may be well suited also to non-military power needs."

> The Rural Electrification Administration, for example, has expressed strong interest in package power plants to fill needs in outlying, high-power-cost areas. Indications are that a large part of the foreign market lies in the range below 30 megawatts of electrical capacity. Such applications as mining operations and outlying industrial plants also appear likely for package power reactors. These and other relatively small power requirements definitely stand to benefit from the successful accomplishment of the Army package power reactors program.[9]

[9] Robert LeBaron, former chairman of the Military Liaison Committee to the A.E.C., has said that "Industry by and large is more interested in the smaller package-type reactors than it is in the very large ones."—Copyrighted interview in *U. S. News & World Report*, June 25, 1954, p. 68.

Experiments with various propulsion reactors, designed to meet specific requirements of the armed forces, are contributing to technological advances necessary to develop civilian uses of nuclear power. A so-called submarine thermal reactor was installed in the first atomic submarine, the *Nautilus*, which began sea trials last January. The second atomic submarine, the *Sea Wolf*, due to be launched in May, is to have a submarine intermediate reactor.[10] A third type of naval atomic power plant, the submarine advanced reactor, which will enable undersea craft to move at higher speeds than the *Nautilus* or *Sea Wolf*, is being developed at the Knolls Atomic Power Laboratory near Schenectady, N. Y.

Following a meeting of the Joint Atomic Energy Committee held aboard the *Nautilus* on Mar. 20, Rep. Van Zandt (R-Pa.), a member of the committee, predicted that nuclear-powered submarines soon would replace most surface warships other than carriers and cruisers. Van Zandt added that large surface craft such as carriers and cruisers would be powered by nuclear engines. Work on a reactor for propulsion of large ships, suspended in 1953, has recently been resumed. Chairman Clarence G. Morse of the Federal Maritime Board on Mar. 16 forecast atomic power for merchant ships in less than five years.[11] The A.E.C. recently approved a one-year study of the possibilities of atomic propulsion for railroad locomotives. The study is to be conducted and financed jointly by the Baldwin-Lima-Hamilton Corp. and the Denver & Rio Grande Western R.R.

Acceleration of research on atomic power for airplanes was noted by President Eisenhower in last January's budget message. The A.E.C. and the Air Force are pushing a joint program to develop a nuclear propulsion system that will combine acceptable altitude and speed performance with high endurance qualities and capacity for extremely long flights. The National Advisory Committee for Aeronautics recently asked Congress to appropriate $4.8 million for an atomic reactor to be used in efforts to develop an atomic airplane engine. Robert LeBaron, former chairman of the Military Liaison Committee to the A.E.C., has predicted atomic power for planes "within the next six or seven years."

[10] A prototype of this reactor is currently being tested at West Milton, N. Y. It is to produce the atomic power that the A.E.C. has offered for sale late this summer.

[11] Norwegian research on merchant marine propulsion reactors was reported two years ago.

International Atomic Energy Developments

WORLD ATTENTION will be focused on the peaceful uses of atomic energy when scientists representing some four score nations assemble at Geneva, next Aug. 8, to exchange experiences and discuss the potentialities of nuclear development. The coming international scientific conference, sponsored by the United Nations General Assembly, forms a part of broad-scale efforts to carry into effect the "atoms-for-peace" plan advanced by President Eisenhower in an address to the Assembly on Dec. 8, 1953.[12]

Although the Soviet Union has agreed to participate in the Geneva conference, it refused last autumn to follow the example of the United States and Great Britain in making a quantity of fissionable materials available for sharing by other countries engaged in atomic research for non-military purposes. International pooling of such materials constituted another part of the atoms-for-peace plan. Formation of an international atomic energy agency is a related part.

President Eisenhower announced on Sept. 6, 1954—on the occasion of the ground-breaking ceremony for the Shippingport reactor—that the United States had "just agreed with a number of other nations to go ahead . . . with the formation of an international agency . . . [to] foster the growth and spread of the new atomic technology for peaceful use." It has been reported that the United States has discussed the question of organizing the proposed International Atomic Energy Agency with Australia, Belgium, Britain, Canada, France, Portugal, and South Africa. A.E.C. General Manager Nichols told the Joint Committee on Feb. 4, moreover, that bilateral agreements were being negotiated with three countries for cooperation in the peaceful uses of atomic energy. Latest reports are that the bilateral agreements will be ready for signature this spring, and that a multilateral treaty on the international agency will be completed during the summer.

Another project in support of the atoms-for-peace plan—a reactor school to train representatives of friendly countries in atomic "know-how"—opened its first session at the Argonne National Laboratory near Chicago on Mar. 14, 1955. Thirty-one scientists and engineers from 19 foreign

[12] For details of the President's proposal, see "New Approaches to Atomic Control," *E.R.R.*, Vol. I 1954, p. 104.

countries, and nine U. S. students, are taking a seven-month course in peaceful applications of nuclear energy.

Other steps to implement the atoms-for-peace plan, in advance of organization of the proposed international agency, have included sale by the United States to India last February of ten tons of heavy water for use in a nuclear reactor to be built near Bombay. The sale coincided with a Joint Atomic Energy subcommittee report approving that action and advocating American assistance for peaceful atomic development in the following additional countries: Australia, Formosa, Greece, Iran, New Zealand, Pakistan, the Philippines, Spain, Thailand, and Turkey. At Bangkok on Feb. 25, Secretary of State Dulles invited the Manila Pact nations to participate in atomic energy training offered by this country and in discussions on distribution of the 220 pounds of fissionable materials that the United States has set aside for the international pool. The Atomic Energy Commission announced a month later that it was planning to install a research reactor at Geneva to demonstrate, to delegates at the August scientific conference, use of the fuel available for international sharing.[13]

Plans to Produce Atom Power in Britain and Russia

A number of other countries have built, or are planning to build, atomic power plants. Twelve nuclear power stations, with an aggregate capacity of 1.5 million to 2 million kilowatts, are to be put in operation in Great Britain in the next ten years at an overall cost of about $840 million. It has been estimated that by 1965 nuclear power will generate in Britain as much electricity annually as would be produced by five or six million tons of coal—enough to meet about one-fourth of the anticipated increase in the country's electric requirements. Minister of Fuel and Power Lloyd said on Feb. 15 that he knew of "no other nation that has yet launched a nuclear power program on this scale."

An experimental nuclear power station under construction in Cumberlandshire in northern England is expected to produce between 40,000 and 50,000 kw, probably by next year, and the output of some of the 12 projected plants may run as high as 200,000 kw. Construction of the first two stations in the ten-year program is to begin in mid-1957, with operation scheduled for 1960 or 1961.

[13] A.E.C. Commissioner Thomas D. Murray has proposed that the United States build an atomic power plant at Hiroshima; Reps. Yates (D-Ill.) and Smith (D-Miss.) have introduced resolutions to that end.

Concern has been manifested in the United States over the fact that Britain apparently has the jump on this country in development of commercial nuclear power. Electricity from the British commercial atomic power stations is expected to cost around 7 mills per kilowatt-hour—about the same as conventionally generated power in this country. Although stepping-up of efforts to attain atomic power for American industry has been proposed, the A.E.C. until recently has felt obliged to give its major attention to the military aspects of atomic energy.

Little is known about Russian accomplishments in use of nuclear power for industrial purposes. Widespread curiosity was aroused by the announcement, Jan. 14, that Moscow was "ready to hand over [at the Geneva conference] the scientific and technical experience [it had] piled up." The Soviet delegate at Geneva is to give information on a 5,000-kw nuclear power plant said to have been in operation somewhere in Russia since last summer.

The Soviet government disclosed on June 30, 1954, that "the first industrial electric station utilizing atomic energy" was furnishing power for the industrial and agricultural needs of nearby regions. Premier Bulganin, addressing the Supreme Soviet on Feb. 9, referred to that plant and added that his government was "now . . . devising a more powerful electrical station working on atomic energy." According to a Reuters dispatch, Andrei Nekrasov of the Soviet Ministry of Power Stations said during a visit to Stockholm on Mar. 7 that the U.S.S.R. had an experimental atomic power station with a capacity of over 50,000 kw.

Activities looking toward industrial application of atomic energy are going forward in numerous other nations. Altogether, probably close to a score of countries have some kind of atomic reactors. Canada is operating three research reactors and plans to have an experimental atomic electric plant ready for operation by 1958. Officials of the Dominion's atomic energy agency have said that Canada may be able to produce atomic power as cheaply as electricity from conventional sources within five to ten years.

Belgium, Brazil, France, Italy, and Switzerland also are understood to be actively experimenting on development of commercial nuclear power. France, which has two research reactors in operation and two under construction, hopes to have a nuclear power plant in service by July 1956.

Atomic Energy and World Power Demands

THE PEACETIME IMPORTANCE of nuclear energy has been highlighted by studies, prepared for the A.E.C. in 1953, which hold out the prospect that the world's population will triple and its energy requirements multiply 20 times by the year 2050. In that case the energy available from conventional fuels would nowhere nearly satisfy the demands of the coming century.

The A.E.C. pointed out, in a statement submitted to the Joint Atomic Energy Committee last June, that although "coal in the United States is abundant . . . its costs and quality cannot be expected to remain at present levels in the face of indicated increases in demands of industry and utilities." The A.E.C. observed also that "Proved reserves of oil and gas are only 12 and 27 times present annual consumption, respectively."

On the other hand, the A.E.C. statement noted, "The energy potentially available in the world's recoverable reserves of uranium has been estimated as perhaps 23 times the energy from world reserves of . . . petroleum, natural gas, and coal." Uranium is thus the world's major fuel reserve. "To meet . . . rapidly expanding energy requirements," John R. Dunning, dean of engineering at Columbia, has noted, "[We] have no other recourse than to turn to atomic fuels in . . . these next decades." [14]

Atomic Power in Backward and Advanced Countries

Nuclear power would be a great boon to underdeveloped countries whose industrial growth is hampered by inadequate or high-cost fuels and power. Atomic power would greatly benefit also those industrially advanced nations that are handicapped by diminishing fuel reserves or mounting fuel and power costs. Belgium and Britain are examples of coal-producing countries plagued by rising production costs.

It has been estimated that the growing requirements of the British economy would cause the consumption by power stations alone of 100 million tons of coal annually in the 1970s. Even if there were a great expansion in coal production, "This would be an almost impossible burden on the

[14] John R. Dunning, "Prospects for Use of Atomic Energy in Generation of Electric Power," *Edison Electric Institute Bulletin*, July 1954, p. 241.

British coal industry, whose total production in 1954 was 224 million tons." [15] The problem is not a shortage of coal. "The trouble is that with the present labor force and state of mechanization . . . [the British] cannot get enough out of the ground." [16]

In such countries, and in others where inadequate resources boost power costs, the need for nuclear power is considerably more urgent than in a country like the United States. Nations or regions able to supply less than one-half their consumption of coal and oil from indigenous sources include: Algeria, Argentina, Ceylon, Denmark, Finland, Greece, French Morocco, Italy, Norway, Pakistan, Portugal, and Sweden. There are places in the world, A.E.C. Chairman Strauss told the National Press Club at Washington on Jan. 11, "where, even today, such [atomic] power as we can now produce would compete with energy from the burning of coal and oil."

Estimated power costs in Belgium, for example, are 9-10 mills per kwh; in France, 12-14 mills; in Japan, 20 mills. It is evident, as former A.E.C. Commissioner Henry D. Smyth has pointed out, that the cost of nuclear power may well be competitive with these foreign costs long before it can compete with American costs of 4-7 mills per kwh.[17] Eugene M. Zuckert, another former member of A.E.C., told an inter-American conference of businessmen in New Orleans on Mar. 2 that "packages of atomic power" were the key to industrializing backward countries.

Used in such areas, nuclear power, it has been suggested, would have the supplementary effect of enlisting support for American foreign policy. A rise in the living standards of backward countries where nuclear power had been introduced would "serve as a most effective bulwark against the spread of Communism." [18] Sen. Jackson (D-Wash.), a member of the Joint Atomic Energy Committee, said on

[15] *British Record*, Feb. 18, 1955, p. 3.

[16] Franz E. Simon, "Nuclear Power: A British View," *Bulletin of the Atomic Scientists*, May 1953, p. 127.

[17] Henry D. Smyth, "Industrial Application of Atomic Energy," *Journal of Business*, October 1954, p. 319. Economists Walter Isard of the Massachusetts Institute of Technology and Robert Kavesh of Dartmouth have directed attention, however, to (1) the high capital costs and interest charges involved in construction of nuclear power plants in underdeveloped areas and (2) the lack of skilled personnel and complementing industrial facilities. Such obstacles have made them skeptical about "grandiose ideas for a nuclear-powered industrialization of . . . [underdeveloped] economies."—"Some Economic Consequences of Nuclear Power," *Annals of the American Academy of Political and Social Science*, November 1953, p. 65.

[18] Clarence E. Larson, director, Oak Ridge National Laboratory, address before Manufacturing Chemists Association, White Sulphur Springs, W. Va., June 4, 1954.

Mar. 1 that it was particularly desirable to build atomic power plants in Asia, where lack of electricity had held up industrialization and in turn had prevented improvement of living standards. John Jay Hopkins, president of General Dynamics Corp., which built the *Nautilus*, recently termed the idea of helping backward countries to obtain atomic power "a marvelous psychological approach against Communism." Other countries, said Hopkins, were "waiting to see what we will do." [19]

Nuclear Energy and Development of New Industries

Most interest in peaceful application of atomic energy centers around its use to generate power. Some observers believe, however, that its influence in bringing about the development of new products, new industries, and new processes may have an even greater impact on the economy.[20] An official of the Atomic Energy Commission has likened the possible effects of atomic energy on the economy to those produced by advent of the automobile.

> Few people could have foretold . . . the impact of the automobile on our way of life . . . [or] foreseen clearly the growth of the steel industry, the glass industry, [or the] rubber, textiles, and even electric light bulbs that would be necessary to keep pace with this new form of transportation. The cement industry has profited because the automobile has made roads necessary, and the housing construction and the "motel" industries likewise have boomed because cars have made possible suburban living and easier cross-country traveling.[21]

An indication of the present stake of American business in the infant atomic energy industry is given by the growth in gross sales of companies making radiation detection instruments—from about $20 million in 1952 to an estimated $36 million in 1954.

Atomic energy probably has become most familiar to industry, science, and medicine via the medium of radioisotopes. Under the radioisotope distribution program, now in its ninth year of operation, the A.E.C. by the end of 1954 had made over 53,000 shipments to more than 2,300 industrial firms, physicians, medical and educational institutions, federal and state laboratories, and foundations. Some 3,100

[19] Copyrighted interview in *U. S. News & World Report*, Mar. 18, 1955, p. 96.

[20] "It seems hardly possible . . . that research will fail to uncover a better method of harnessing the power of the atom than using it to boil water, to make steam, to drive electricity generators."—"Atomic Energy and Industry," *The Economist*, July 31, 1954, p. 380.

[21] George G. Manov, office of the assistant general manager for research and industrial development, A.E.C., address before National Association of Manufacturers, St. Louis, Nov. 17, 1954.

shipments of radioisotopes had been made to 40-odd foreign countries.

The use of radioisotopes to diagnose thyroid malfunctioning, detect brain tumors, and treat blood disorders is fairly well known, but their use by industry to reduce costs and to improve process and quality control is far less known. Radioisotope thickness gauges, used by companies making tires and abrasive papers, reportedly have saved those concerns as much as $100,000 a year. Other radioisotopes are used to measure engine wear and to open and close pipeline valves in certain automated operations. Radioisotopes have been utilized in agriculture to improve fertilizer application and poultry feeding.

Use of atomic energy to preserve foods by means of ionizing radiations has stirred considerable interest because of the advantages it provides over preservation by freezing, refrigeration, or heating. In radiation—or so-called cold—sterilization of food, radiations from isotopes or X-ray-type machines act as invisible bullets to destroy such microorganisms as molds. Samuel A. Goldblith of the Massachusetts Institute of Technology reported to a meeting of the Atomic Industrial Forum, in New York a year ago, that experiments at M.I.T. had shown it was possible to keep sterilized hamburgers in a refrigerator at 40° F. for more than 100 days with no signs of spoilage.

The Army Quartermaster Corps has undertaken an extensive study of food sterilization by radiation. In many military operations and installations refrigeration facilities are either completely lacking or of very limited capacity. A radiation facility capable of sterilizing 20 tons of potatoes in an hour, thereby giving them a shelf life of two years, has been designed by the University of Michigan under an A.E.C. contract.

Drugs, blood serum, and related materials also can be sterilized by radiation more quickly and more easily than by conventional methods. Goldblith reported that sterilized segments of the human aorta had been successfully used in surgical transplants on 40 persons. Anticipated applications of atomic energy in medicine include use of small nuclear reactors to treat cancer at a patient's bedside.

Economic Feasibility of Nuclear Power

THE FUTURE of atomic power is no longer primarily a problem of technology; it has become a problem of economics. Theoretically almost any of the reactors now in existence could be used to generate electricity, but they would not produce economic power.[22] The question is how to produce nuclear electric power at a cost comparable to the cost of electric energy generated from the conventional sources.

How soon atomic power will be competitive with conventional power depends in part on who is doing the prophesying. Estimates range from a forecast made Feb. 28 by Rep. Durham (D-N. C.), vice chairman of the Joint Atomic Energy Committee—that nuclear power should be commercially competitive within five years—to more conservative predictions of around 20 years. Some experts have predicted that by 1975 as much as 10 per cent of all the country's electricity may be coming from atomic plants. A.E.C. Chairman Strauss has commented:

> Some engineer-economists foresee that by 1960 . . . perhaps 10 per cent of the new power plants on the drawing boards will have specifications for nuclear reactors, instead of coal, oil, or gas-fired boilers. These same experts say that by 1980 perhaps half of the new plants will use fissionable materials as fuel. However, I think these forecasts are too conservative.[23]

The problem of developing an economic nuclear reactor is largely one of reducing costs for capital investment and fuel. Each type of reactor has advantages and disadvantages. Among the questions still to be answered are: What kind of reactor will be most efficient, and what will be the capital and operating costs? "The final answer," Dean Dunning of Columbia has said, "must come from actually building and testing some of these many types of plants in order to get the basic experience as to . . . costs, operating life, and all the factors that normally must enter into . . . planning." [24]

[22] The world's first significant amount of electricity generated by a nuclear reactor was produced on Dec. 21, 1951, when energy from the A.E.C.'s experimental breeder reactor No. 1 at the National Reactor Testing Station in Idaho lighted four electric bulbs.

[23] Address before Veterans of Foreign Wars, Philadelphia, Aug. 5, 1954. In a statement submitted to the Joint Atomic Energy Committee last June, the A.E.C. observed, however, that "Only a small number of full-scale privately owned and operated power reactors are likely to be on the line before 1965."

[24] John R. Dunning, "Prospects for Use of Atomic Energy in Generation of Electric Power," *Edison Electric Institute Bulletin*, July 1954, p. 246.

PROBLEM OF MAKING ATOM POWER COSTS COMPETITIVE

For atomic power to become widely competitive with conventional power, nuclear generating costs would have to be reduced to a range of 4-7 mills per kwh. Federal Power Commission data show that the average production cost of steam-generated electric power for the major utility systems in the United States is a little over 7 mills per kwh. But a nuclear power station would have to compete, not with the plants making up this general average, but rather with the new postwar thermal plants; 70 per cent of all the new plants generate electricity in the 4-7 mill range.

Nuclear power at 4 mills a kwh would be competitive anywhere in the United States, except in parts of the Southeast and South Central regions that are fueled by low-cost coal and natural gas. Even at 7 mills, nuclear power would be competitive in parts of the Northeast, Southeast, and North Central regions. A 6-mill power cost, it has been estimated, would capture one-half of the market served by conventional power plants built since World War II.

Estimates of the cost of the electricity to be produced by the Shippingport reactor have ranged from 12 to 21 mills per kwh. The power delivered by the submarine reactor at the National Reactor Testing Station in Idaho—the prototype of the unit installed in the *Nautilus*—costs "about ten times as much as it would if . . . bought . . . from the Idaho Power Co." [25]

The report made to the A.E.C. by one of the four original industry study groups—Commonwealth Edison Co.-Public Service Co. of Northern Illinois—estimated that the cost of building an atomic power plant might range, depending on the type of reactor, from $40 million for a 60,000-kw plant to $118 million for a 240,000-kw plant, or $667 and $492 per kw of generating capacity, respectively.[26] Plants employing other types of reactors have been estimated to cost as little as $300-$350 per kw. In contrast, the cost of a conventional electric power plant is about $170 or $180 per kw. Prices of nuclear fuels have not been made public, but a figure of around $20 a gram or about $9,000 a pound for uranium-235 has been mentioned in press reports.

Hopes for lower atomic power costs are fostered by the

[25] Former A.E.C. Commissioner Smyth, address before American Institute of Chemical Engineers, Washington, D. C., Mar. 9, 1954.

[26] "Power Generation Using Nuclear Energy," *Reports to U. S. Atomic Energy Commission on Nuclear Power Reactor Technology* (May 1953), pp. 16-17, 37-38.

possibility of using so-called breeder reactors, which produce as much nuclear fuel as they consume, or even more than they consume. W. Kenneth Davis, director of the A.E.C.'s reactor development division, said on Feb. 27 that breeder reactors could be built by private industry by 1960, and Walker L. Cisler, president of the Detroit Edison Co., told a New York University conference on Mar. 12 that a large breeder reactor was now feasible. He exhibited a model of a 100,000-kw breeder plant that would cost $50 million or more to build.

Barriers to Early Attainment of Commercial Power

Despite the progress made toward commercial nuclear power, numerous obstacles remain. For one thing, nuclear engineering knowledge is still at the stage where new designs must be tested by experiment rather than by mathematics. And the vast expense involved in atomic energy experiments makes for hesitancy.[27] Such considerations mean that private investment in atomic power in the near future is likely to be induced more by public service motives than by expectation of short-term profit.

Some technical problems also remain to be solved. Aside from the question of deciding which type of reactor is most suitable, there are such problems as determining how long a reactor will run without a major overhaul, and developing a cheap method of reprocessing and refabricating nuclear fuel. Then there is the question of the hazards involved in operation of reactor power plants.

"It is as yet by no means clear," Chairman Strauss testified on Jan. 31, "whether industry can obtain public liability insurance from private insurance carriers in amounts that are reasonably sufficient to cover reactor hazards." Rep. Cole (R-N. Y.), chairman of the Joint Committee in the 83rd Congress, has suggested that it may be necessary for the government to reinsure part of such policies or to offer some insurance itself. The A.E.C. held a briefing of ten insurance executives in Washington, Mar. 15-16, to give them information necessary for a review of the problems involved in insuring private operation of reactors.

The level of prices the government will pay private com-

[27] "How can there be real room for experimentation, for trying out this or that cute but possibly unworkable idea, on plants in the $100 million class?"—Alvin M. Weinberg (director of research, Oak Ridge National Laboratory), "How Shall We Establish a Nuclear Power Industry in the United States?" *Bulletin of the Atomic Scientists*, May 1953, p. 123.

panies for any special nuclear materials they produce may be another obstacle to early development of commercial nuclear power. Revenue from such sales was counted on to defray a large share of the initial costs of atomic power plants, but it has been objected that present prices are too low to permit fulfillment of that expectation. Walker Cisler, appearing before the Joint Committee on Feb. 7 as spokesman for Atomic Power Development Associates, said that the prices fixed by the A.E.C. were only about half what he had expected them to be. Guarantee of these prices by the A.E.C. for only seven years also may tend to deter industrial participation, Chairman Strauss has said.

Another barrier to rapid attainment of atomic power is the secrecy surrounding much of the technical information which would be useful to private industry. James G. Beckerley, former A.E.C. director of classification, told the Joint Committee on Feb. 7 that the "scope of restricted data" should be reduced, because industrial development would be "greatly handicapped by government control of the dissemination and handling of technical data of potential commercial value." Francis K. McCune, general manager of General Electric's atomic products division, asserted on Mar. 3 that downgrading of secret data would "produce greater advances by American industry than the increased 'leakage' of information will produce behind the Iron Curtain."

Whether or not the patent provisions of the 1954 Atomic Energy Act will prove another obstacle to the private development of nuclear power—as was feared when the legislation was being debated [28]—remains to be seen. A.E.C. General Manager Nichols indicated before the Joint Committee on Jan. 31 that, although some persons wished that the patent provisions offered more liberal incentives to private enterprise, he had not observed that the law had discouraged potential applicants. "In the utility field," he noted, "they don't worry too much about patents."

[28] See "Public Power," *E.R.R.*, Vol. II 1953, p. 482.